Fabrication process of Mo/Au TES at RT

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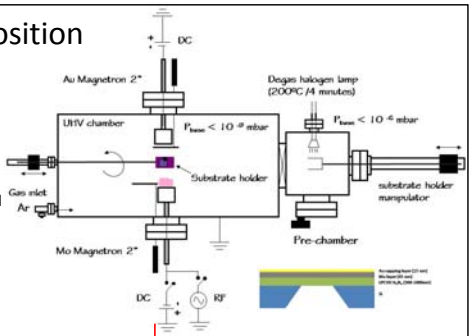
Abstract

We report on the fabrication details of TES based on Mo/Au bilayers. The Mo layer is deposited by radio frequency (RF) sputtering and capped with a sputter deposited thin Au protection layer. Afterwards, a second Au layer of suitable (lower) resistivity is deposited ex-situ by e-beam evaporation, until completion of the total desired Au thickness. The deposition was performed at room temperature (RT) on LPCVD Si_3N_4 membranes. Such a deposition procedure is very reproducible and allow controlling the critical temperature (*Tc*) and normal electrical resistance (R_N) of the Mo/Au bilayer. The process is optimized to achieve low stress bilayers, thus avoiding the undesirable curvature of the membranes. Bilayers are patterned using photolithographic techniques and wet etching procedures. Mo superconducting paths are used to contact the Mo/Au bilayers, thus ensuring good electrical conductivity and thermal isolation. The entire fabrication process let to stable and reproducible sensors with required and tunable functional properties.

Mo/Au bilayer deposition

Sputtering: Mo and Au protective layer

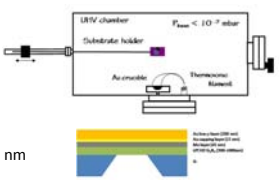
- RT deposition.
- On LPCVD Si_3N_4 membranes cleaned by KOH (20% wt at 90ºC).
- **Mo superconducting unstrained layer:**
  DC or RF (1 Å/s).
  p(Ar) = 5 x 10^{-3} mbar.
  thickness : 40–200 nm
- **Au protective layer** :
  DC (1.5 Å/s).
  p(Ar) = 6 x 10^{-3} mbar.
  thickness : 15 nm
- Homogeneity : 1".

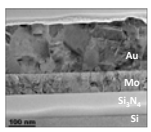


Ex-situ transfer

E-beam: Au with low ρ

- RT deposition.
- Base pressure < 10^{-7} mbar.
- Rate : 2 Å/s.
- Thickness (d): 100 nm < d < 200 nm

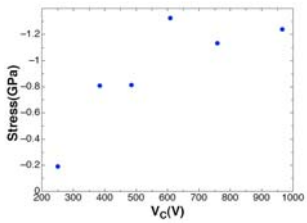




Tranversal TEM image of a Mo/Au bilayer showing a neat interface between Mo and Au.

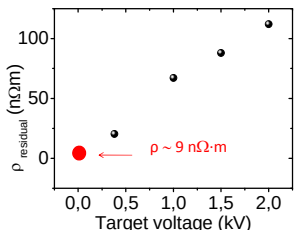
Mo/Au bilayer properties optimization

Stress



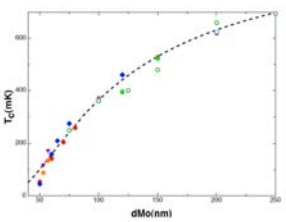
Residual stress as a function of the target bias voltage Vc.

Normal resistance (R_N) of Au layers



Residual resistivity of 150nm Au layers sputtered at different target voltages (black symbols) and e-beam evaporated (red symbols).

Critical temperature (T_C)

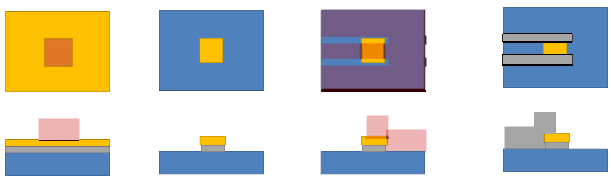


Dependence of the Tc on Mo thickness for a fixed Au thickness of 115nm (empty symbols) and 200nm (full symbols).

Thermal stability

Mo/Au bilayers are stable at temperatures up to 300ºC. Further details can be found in **poster 144.**

Sensor patterning

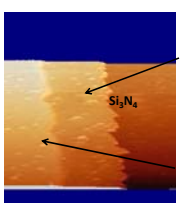


1) Spin coating of the bilayer and UV lithography to define the sensor area (300x300 μm²).

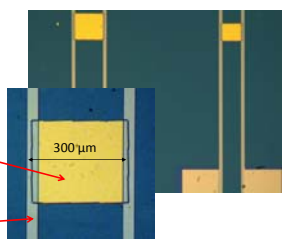
2) Wet etching of bilayer metals. (Au : KI + I_2 + DI, Mo : H_3PO_4 + HNO_3+ H_2O_2 + DI).

3) A second UV lithography is performed to fabricate the SC paths.

4) SC paths : DC Mo deposition (200nm) and lift-off in acetone.

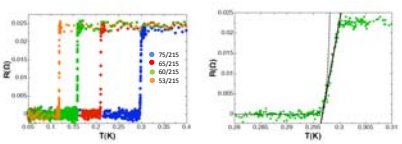


Atomic Force Microscopy image of the patterned sensor. The Au "overhang" is clearly observed.



Optical microscope image of the patterned sensor.

Sensors characteristics



Left : transition curves of some patterned bilayers with different thickness ratio. Right : α calculation for a lithographed bilayer (75nm/215 nm). Full symbols represent R(T) measurements, solid line correspond to T_c calculation and dash line to the fit of experimental data for T <T_c.

Example:

d(Mo/Au) : 53/215
Tc ~ 100 mK
Transition width ~ 3 mK
α ~ 600
R_N ~ 25 mΩ

Sharp and reproducible transitions!

Conclusions

- A deposition process of Mo/Au sensors is developed, showing an excellent control of the TES basic functional properties – T_C, R_N and α– . The process is carried out at RT by UHV sputtering and e-beam deposition.
- The sensors consist on three layers: a sputtered Mo layer, a 15 nm protective sputtered Au layer and a low resistivity evaporated 200 nm Au layer. The extra Au layer, deposited in a different chamber, is needed to obtain low values of R_N.
-- A simple lithographic route is followed to achieve normal metal conditions on bilayer boundaries. Sharp and reproducible transitions are achieved in sensors deposited in freestanding membranes (reaching α values of 600).

References

R. González-Arrabal et al., "Mo/au bilayers deposited by sputtering at room temperature for transition edge sensors fabrication" Journal of Low Temperature Physics, 151 239 (2008).
L. Fàbreg- a, et al., "Size and dimensionality effects in superconducting Mo thin films" Supercond. Sci. Technol. 24 075014 (2011).

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